PART 1 - GENERAL

1.1 REFERENCES

The publications listed below form a part of this specification to the extent referenced. The publications are referred to in the text by the basic designation only.

AIR MOVEMENT AND CONTROL ASSOCIATION, INC. (AMCA)

AMCA 500	(1991) Louvers, Dampers and Shutters
AMCA 501	(1985) Application Manual for Air Louvers

AMERICAN SOCIETY FOR TESTING AND MATERIALS (ASTM)

ASTM A 167	(1996) Stainless and Heat-Resisting Chromium-Nickel Steel Plate, Sheet, and Strip
ASTM A 653/A 653M	(1996) Steel Sheet Zinc-Coated (Galvanized) or Zinc-Iron Alloy-Coated (Galvannealed) by Hot-Dip Process
ASTM B 209M	(1995) Aluminum and Aluminum-Alloy Sheet and Plate (Metric)
ASTM B 209	(1996) Aluminum and Aluminum-Alloy Sheet and Plate
ASTM C 423	(1990; Rev. A) Sound Absorption and Sound Absorption Coefficients by the Reverberation Room Method
ASTM C 553	(1992) Mineral Fiber Blanket Thermal Insulation for Commercial and Industrial Applications
ASTM C 1071	(1991) Thermal and Acoustical Insulation (Mineral Fiber Duct Lining Material)
ASTM E 90	(1997) Laboratory Measurement of Airborne Sound Transmission Loss f Building Partitions and Elements
ASTM E 96	(1995) Water Vapor Transmission of Materials
ASTM E 437	(1992) Industrial Wire Cloth and Screens (Square Opening Series)

NATIONAL FIRE PROTECTION ASSOCIATION (NFPA)

NFPA 90A	(1996) Installation of Air Conditioning and Ventilating Systems

SHEET METAL & AIR CONDITIONING CONTRACTORS' NATIONAL ASSOCIATION, INC. (SMACNA)

SMACNA DCS	(1985) HVAC Duct Construction Standards - Metal and Flexible

UNDERWRITERS LABORATORIES INC. (UL)

UL 181	(1996; R 1996) Factory-Made Air Ducts and Air Connectors
UL 555	(1995; Bul. 1996) Fire Dampers
UL 555S	(1996) Leakage Rated Dampers for Use in Smoke Control Systems
UL 723	(1996) Surface Burning Characteristics of Building Materials

1.2 RELATED REQUIREMENTS

Section 15050, "Basic Mechanical Materials and Methods," applies to this section with the additions and modifications specified herein.

1.3 PRESSURE CLASSIFICATION

SMACNA DCS, Section 1, and as indicated.

1.4 DESIGN REQUIREMENTS

1.4.1 Duct Span Versus Reinforcement Schedule

Submit maximum duct dimension, board stiffness rating, board thickness, type and spacing of reinforcement, and maximum duct static pressure.

1.4.2 Sound Pressure Level Rating

Submit for inlets and outlets including diffusers, registers and grilles.

1.5 SUBMITTALS

Submit the following in accordance with Section 01330, "Submittal Procedures."

1.5.1 SD-01, Pre-construction Submittals

a. Diffusers, registers and grilles

b. Duct hangers and supports

Submit a schedule of inlets and outlets indicating location, catalog model number, manufacturer, dimensional information, sound pressure level rating, nominal rated volumetric flow rate liter per second

cfm, neck or face velocity at specified cfm, pressure drop at specified cfm, throw and drop for outlets, range for diffusers, and maximum and minimum cfm modulation.

1.5.2 SD-02, Shop Drawings

a. Locations of test holes

b. Duct hangers and supports details

1.5.3 SD-03, Product Data

a. Balancing Dampers

Acoustical duct lining Flexible ducts and connectors Insulation and vapor barrier Duct-liner adhesives Diffusers, registers and grilles, and Metal ducts Test holes

1.5.4 SD-06, Test Reports

Sound pressure level rating for diffusers if noise or rattling occurs
Air duct leakage tests

1.5.5 SD-07, Certificates

a. Fire dampers

1.5.6 SD-08, Manufacturer's Instructions

a. Ductwork and ductwork accessories

1.6 QUALITY ASSURANCE

1.6.1 Modification of References

SMACNA Duct Construction Manuals: The SMACNA recommendations shall. be considered as mandatory requirements. Substitute the word "shall" for the word "should" in these manuals.

1.6.2 Ductwork and Ductwork Accessories

Submit manufacturer's instruction including job inspection checklist, methods of on-site storage and handling, and recommended repair methods.

PART 2 - PRODUCTS

2.1 METAL DUCTS

2.1.1 Steel Ducts

ASTM A 653/A 653M galvanized steel sheet, lock-forming quality; coating designation G90. ASTM A 167.

2.1.2 Duct-Liner Adhesives

SMACNA DCS, fire-resistant adhesive.

2.2 DUCTS OF PRESSURE CLASSES

Ducts of pressure classes 4 to 10 inch water gage. Construct ducts of galvanized steel.

2.2.1 Construction

Duct construction, metal gages, and hangers and support reinforcements shall conform with the SMACNA DCS. Ducts shall not pulsate or vibrate when in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork. Air leakage shall be less than one percent of the system capacity. Curved elbows shall have a centerline radius not less than 1 1/2 times the width of ducts.

2.2.2 Joints

Construct joints to meet the requirements of the leakage test specified herein. Duct components shall fit so that joints are not mismatched. Do not use duct sealant and tape to compensate for mismatched connections. Longitudinal locks or seams known as "button-punch snap-lock" will not be permitted. Apply fire-resistant sealing compound to exposed male part of fittings collars so that sealer will be on inside of joint and fully protected by the metal of the duct and fitting. Apply one brush coat of sealing compound over outside of joint to at least 2 inch band width covering screw heads and joint gap. When tape is used, apply a single wrap of a duct tape over the wet sealer. Tape provided shall be as recommended by the sealer manufacturer to permit proper curing of the sealer. Dents in the male portion of the slip fitting collar will not be acceptable.

2.2.3 Fittings

Square elbows, round elbows, fittings, branch take offs, transitions, splitters, duct volume dampers, fire dampers, flexible connections, and access doors shall conform with the SMACNA DCS, Section 2.

2.2.3.1 Test Holes

Provide factory fabricated, airtight, and non-corrosive test holes with screw cap and gasket. Provide extended neck fittings to clear insulation.

2.2.3.2 Round Elbows

Provide 45 degree and 90 degree elbows of 2 piece die stamped construction for ducts 8 inches or less in diameter. For ducts over 8 inches in diameter, provide 5 mitered piece for 90 degrees and 3 mitered piece for 45 degrees.

2.2.4 Round and Oval Ducts

Make joints between sections of duct and fittings with mating angle rings, beaded sleeve joints or slide-on gasketed flange connections. Slide-on gasketed flange joints shall consist of two mating flange rings. The flanges shall be fabricated with an integral mastic to make them self-sealing. The flanges shall be joined to the duct with spot-welds or self-tapping screws. A neoprene gasket shall be used between the flanges. Final joining of the slide-on flange connection shall be made with four bolts for flat-oval ducts. A single-bolt closure ring shall be used to complete the round slide-on flange connection. Select duct gage for size and pressure class as recommended in SMACNA DCS, Section 3.

2.2.5 Rectangular Ducts

Make joints between sections of duct and between ducts and fittings with mating angle flange joints, other joints recommended in SMACNA DCS, Section 1, or slide-on gasketed flange connections. Reinforce at the joints and between the joints as recommended by SMACNA. The slide-on gasketed flange connections shall consist of two mating flange frames. The frames shall be made up from four pieces of straight roll formed flange and four corner pieces. The flange shall be fabricated with an integral mastic to make them self sealing. The corner pieces shall be made with a down set to allow the corner of the duct to protrude past the corner piece. The frame shall be joined to the duct wall with spot welds or self-tapping screws. A butyl gasket shall be used between the flanges. Gasket must pass UL 723 and shall not contain vegetable oils, fish oils or any other type vehicle that will support fungal and/or bacterial growth associated with dark areas of ductwork. The connection shall be completed using drive-on corner clips and snap on cleat. Cleat spacing and fastener spacing shall be as dictated by the manufacturer. Where joint systems recognized by SMACNA as propriety are utilized, follow the manufacturer's construction and installation guidelines.

2.3 DUCTS OF PRESSURE CLASSES 3 INCH WATER GAGE OR LESS

Construction, metal gage, hangers and supports, and reinforcements shall conform with SMACNA DCS, except that ducts with pressure classifications below 2 inch water gage that are located outside of the conditioned space shall have a seal class C. Ductwork shall be airtight and shall not vibrate or pulsate when system is in operation. Pressure sensitive tape shall not be used as a primary sealant on ductwork with pressure classifications above one inch water gage. Air leakage shall be less than 5 percent of the system capacity. Construct ductwork of galvanized steel.

2.3.1 Curved Elbows

Make a centerline radius not less than 1 1/2 times the width or diameter of the duct.

2.3.2 Laps

Make laps at joints in the direction of air flow. Space button-punch or bolt-connection in standing seams at fixed centers not greater than 6 inches. Longitudinal locks or seams, known as "button-punch snap-lock," may be used in lieu of Pittsburg Lock.

2.3.3 Fittings

Elbows, Vaned elbows, take-offs, branch connections, transitions, splitters, volume dampers, fire dampers, flexible connections, and access doors shall conform with SMACNA DCS, Section 2. Provide factory fabricated airtight, and non corrosive test holes with screw cap and gasket.

2.3.4 Acoustical Duct Lining

Flexible or rigid mineral fiber lining conforming to ASTM C 1071. Lining shall not be less than one inch thick. Use only in return elbows to packaged rooftop units

2.4 FLEXIBLE DUCTS AND CONNECTORS

UL 181, Class I, UL listed, SMACNA DCS, and additional requirements herein specified. Provide to connect between rigid ducts and outlets or terminals. There shall be no erosion, delamination, loose fibers, or odors from the ducts into the air stream. At 250 degrees F, minimum rating pressures shall be 9 inches water positive and 1-1/2 inch negative, up to 4,000 feet per minute velocity. Flexible ducts shall be maximum of 3 feet in length. No bends shall be made with flexible ductwork, flexible ductwork shall only be used for minor offsets to align diffusers with ceiling grid.

2.4.1 Materials

Interlocking spiral or helical corrugated type constructed of corrosion-resistant steel or non-collapsible fire-retardant, chloroprene or chlorosulphonated polyethylene impregnated, minimum one 30 ounces per square yard woven mineral fabric.

2.4.2 Insulation and Vapor Barrier

ASTM C 553 Type 1, Class B-2, minimum one inch nominal thickness and three-quarter lb./cu. ft. density. Sheathe insulation with a vapor barrier having a maximum water vapor permeance of 0.20 perm in accordance with ASTM E 96, Procedure A. Coat ends of insulation with cement to prevent erosion and delamination.

2.4.3 Joints

Make airtight slip joints, seal with pressure-sensitive vapor-seal adhesive tape or duct sealer, anal secure with sheet metal screws. To prevent insulation compression, place thick 2 inch wide by one inch thick closed cell foam plastic spacers over joints under vapor barriers. To provide a vapor tight joint, provide a stainless steel clamp over such spacers.

2.5 DIFFUSERS, REGISTERS, AND GRILLES

2.5.1 Material and Finishes

Provide factory-furnished diffusers, registers, and grilles constructed of steel or aluminum. Exterior and exposed edges shall be rolled, or otherwise stiffened and rounded. Steel parts shall be factory zinc phosphate treated prior to priming and painting or have a baked-on enamel finish. Colors shall be selected or approved by Contracting Officer. For ductwork of pressure classes 4 to 10 inch water gage, provide sponge-rubber gasket between flanges and wall or ceiling.

2.5.2 Sound Pressure Level

Manufacturer certified sound pressure level rating of inlets and outlets.
Conform with the following permissible room sound pressure levels:

NC (Maximum)	Typical Application
20	all spaces

2.5.3 Throw

The distance from the diffuser, register, or grille to the point which the air velocity falls below 100 feet per minute.

2.5.4 Drop

Maximum drop of air stream shall not be within 6 feet of the floor at the end of the throw.

2.5.5 Ceiling Diffusers

Provide diffusers with variable face patterns to provide throw patterns required. Diffusers will be 4-way throw unless designated otherwise on the contract drawings by schedule or by flow arrows. Provide factory-fabricated, single key, volume dampers for diffusers installed in hard ceilings, provide duct mounted balancing dampers for diffusers mounted in lay-in ceilings.

2.5.6 Square, and Rectangular Diffusers

Construct each ceiling diffuser of four or more concentric elements designed to deliver air in a generally horizontal direction without excess smudging of the ceiling. Interior elements of ceiling diffusers may be square, or rectangular as manufacturer's standard.

2.5.7 Registers

Double-deflection supply registers. Provide manufacturer-furnished volume dampers. Volume dampers shall be of the group-operated, opposed-blade type and key adjustable by inserting key through face of register. Operating mechanism shall not project through any part of the register face. Automatic volume control devices will be acceptable. Provide exhaust and return registers as specified for supply registers, except that exhaust and return registers shall have a single set of non-directional face bars or vanes having the same appearance as the supply registers. Set face bars or vanes at 30 degrees.

2.5.8 Grilles

Construct and finish as specified above for registers, except that volume dampers shall be omitted.

2.6 DUCT SLEEVES, PREPARED OPENINGS, AND CLOSURE COLLARS

2.6.1 Duct Sleeves

Fabricate from minimum 20 gage galvanized steel. Where sleeves are installed in bearing walls, provide structural steel sleeves as indicated. Size sleeves to provide one inch clearance between duct and sleeve or between insulation and sleeve for insulated ducts.

2.6.2 Prepared Openings

Provide one inch clearance between the duct and the sleeve, or one inch clearance between insulation and sleeve for insulated ducts except at grilles, registers, and diffusers.

2.6.3 Packing

ASTM C 553, Type 1, Class B-2, mineral fiber.

2.6.4 Closure Collars

Four inches wide minimum, fabricated from minimum 20 gage galvanized steel.

2.6.5 Deflectors

Factory-fabricated and factory- or field-assembled units consisting of curved turning vanes for uniform air distribution and change of direction with minimum turbulence and pressure loss. Provide curved vanes for square elbows. For round ducts taking off from rectangular ducts, provide factory fabricated, galvanized sheet metal, spin-in fittings. These fittings shall have scoop extractors, butterfly dampers, and locking quadrant operators.

2.6.6 Fire Damper And Control Access Doors

Door shall be rigid and airtight with neoprene gaskets and two or more chrome-plated with copper or nickel base steel hinges and quick fastening locking devices. Provide doors as large as practical. Mount doors, if possible, so that air pressure holds them closed. As an alternative, removable access doors may be used. These access doors shall be constructed from stamped sheet metal and consist of an inner and outer door panel. Where insulated doors are needed, the inner door shall consist of two panels spot-welded together which totally encapsulate fiberglass insulation. The inner and outer doors shall be joined by bolts and threaded handles in such a configuration that the panels can be drawn together to secure the door to the duct in a sandwich fashion. The handles shall be high impact plastic with threaded metal inserts. Conical springs shall be used between the door panels to facilitate installation and removal of the door. Neoprene gasket shall be used around the outside edge of the inner or outer panel, but not both, to seal the door. This type of door is approved for use on rectangular, round and flat-oval ductwork.

2.6.6.1 Back draft Dampers (Gravity Dampers or Shutters)

Factory-fabricated, with statically balanced blades that open automatically when the fan starts and close by gravity when the fan stops. Provide the edges of blades with felt or rubber strips to prevent rattling.

2.6.6.2 Manual Volume Dampers

Balancing, factory-fabricated type. Equip dampers with accessible mechanism such as quadrant operators or 3/16 inch rods brought through the side of ducts with locking sets crew and bushing. where quadrant operators are furnished, provide chrome plated or enamel painted type with exposed edges rounded.

2.6.6.3 Fire Dampers

Provide in accordance with UL 555.

2.6.6.4 Automatic Smoke-Fire Dampers

Multiple blade type, 180 degrees F fusible fire damper link; smoke damper assembly to include pneumatically powered operator. UL 555 as a 1 1/2 hour rated fire damper; further qualified under UL 5555 as a leakage rated damper. Leakage rating under UL 555S shall be no higher than Class II or III at an elevated temperature Category B 250 degrees F for 30 minutes. Pressure drop in the damper open position shall not exceed 0.1 inch w.g. with average duct velocities of 2500 fpm.

PART 3- EXECUTION

3.1 DUCTWORK

Air distribution systems shall operate with no chatter or vibration.

3.1.1 Field Changes to Ductwork

Those required to suit the sizes of factory-fabricated equipment actually furnished, shall be designed to minimize expansion and contraction. Use gradual transitions in field changes as well as modifications to connecting ducts.

3.1.2 Dampers

When installed on ducts to be thermally insulated, equip each damper operator with stand-off mounting brackets, bases, or adapters to provide clearance between the duct and operator not less than the thickness of insulation. Stand-off mounting items shall be integral with the operator or standard accessory of damper manufacturer.

3.1.3 Deflectors

Provide in square elbows, duct-mounted supply outlets, take-off or extension collars to supply outlets, and tap-in branch-off connections. Adjust supply outlets to provide air volume and distribution as indicated.

3.1.4 Fire Dampers

Install in accordance with manufacturer's instructions for condition of UL 555 and NFPA 90A. Locate as indicated and provide surface penetration sleeves in accordance with approved detail drawings.

3.1.5 Access Doors

Provide for fire dampers, coils, thermostats, temperature controllers, other concealed apparatus requiring service and inspection in the duct systems.

3.1.6 Duct Sleeves, Prepared Openings, and Closure Collars

Provide for ductwork penetrations in floors, walls, and partitions through which metallic ductwork passes.

a. Duct Sleeves: Fill space between duct and sleeve or between insulation and sleeve for insulated ducts with mineral fiber, except at grilles, registers, and diffusers.

b. Prepared Openings: Fill space between duct and opening or between insulation and opening for insulated ducts with mineral fiber, except at grilles, registers, and diffusers.

c. Closure Collars: Fit collars snugly around ducts or insulation. Grind edges of collar smooth to preclude tearing or puncturing insulation covering or vapor barrier. Provide nails with maximum 6 inch centers on collars.

3.1.7 Duct Hangers and Supports

SMACNA DCS, Section 4. Attach supports only to structural framing members and concrete slabs. Do not anchor supports to metal decking unless a means is provided and approved for preventing the anchors from puncturing the metal decking. Where supports are required between structural framing member, provide suitable intermediate metal framing. Provide retainer clips where C clamps are used.

3.18 Flexible Ducts

Support ducts by hangers every one 3 feet, unless supported by ceiling construction. Stretch flexible air ducts to smooth out corrugations long radius elbows.

3.1.9 Flexible Connectors

Provide flexible connectors between fans and ducts or casings and where ducts are of dissimilar metals as indicated. For round ducts, securely fasten flexible connectors by stainless steel clinch-type draw-bands. For rectangular ducts, lock flexible connectors to metal collars.

3.1.10 Inspection Plates and Test Holes

Provide, where required, in ductwork or casings for all balance measurements. If possible, test holes should be located at least 7.5 times diameters downstream from a disturbance. Extend cap through insulation.

3.1.11 Acoustical Duct Lining (RTU-1 THRU 4 RETURN AIR ELBOWS)

SMACNA DCS, Section 2. Apply lining in cut-to-size pieces attached to interior of ducts with fire-resistant adhesive. Top and bottom pieces shall lap the side pieces. Secure pieces together with welded pins or clips. Do not distort ducts, burn through or mar the finish surface of ducts. Pins and washers shall be flush with the surface of duct liners. Seal breaks and punctures of duct-liner coating with fire-resistant adhesive. Coat exposed edges of the liner at duct ends and other joints where lining will be subject to erosion with a heavy brush coat of fire-resistant adhesive, to prevent delamination of glass fibers.

3.1.12 Flashing

Section 07600, "Flashing and Sheet Metal." Provide waterproof flashing where ducts pass through exterior walls and roofs.

3.1.13 Cleaning of Ducts

Remove all debris and dirt from ducts and wipe clean. Before installing air outlets, force air through entire system at maximum attainable velocity to remove accumulated dust. Provide temporary air filters to protect ductwork which may be harmed by excessive dirt. For large systems, clean duct with high power vacuum machines.

3.2 FIELD QUALITY CONTROL

Administer and direct tests. Furnish instruments, equipment, connecting devices, and personnel for the tests. Notify Contracting Officer 10 days before inspection or testing is scheduled. Correct defects in work. Repeat tests until work is in compliance.

3.2.1 Air Duct Leakage Tests

Perform duct air leakage test in accordance with Section 15950, "HVAC Testing/Adjusting/Balancing."

3.3 SCHEDULE

Provide ductwork from packaged rooftop unit to VAV terminal units with +6 inches water gauge class and low pressure ductwork down stream of VAV units and for exhaust systems to be constructed to 2" inch water gauge class.

END OF SECTION